

**Concrete**  
building for life.

# Concrete Pavement – Defects, Maintenance and Repairs

SWIFT

September 23<sup>rd</sup>, 2025



# Content



- **Introduction to Concrete Defects**
- **Surface Defects**
- **Joint / Crack Deterioration**
- **APPENDIX: Technical Resources**

# **Introduction to Concrete Defects**



# Introduction to Defects - Causes and Examples

Defects in concrete may be caused by many different reasons:

- Wrong concrete design
- Improper batching (mixing)
- Wrong aggregate proportions
- Improper aggregates
- Inadequate support (non-uniform support)
- Improper placing
- Improper finishing
- Improper isolation of fixed objects
- Chemical attack
- IMPROPER CURING**

Deformation of the surface:  
Curling or warping, blistering.

Cracking of the surface:  
Structural failure, shrinkage.

Surface Disintegration:  
Dusting, Scaling, Spalling, Popoffs, Popouts.

Honeycombing:  
Large unconsolidated, segregated concrete

Bugholes:  
Small voids on the surface of vertical concrete



# Investigating Defects

Evaluation of the defects involves:

- Visual examination of the concrete
- Non destructive testing
- Coring in defective areas (if necessary)
- Friction testing

## *Helpful to know:*

- Time of year concrete was placed
- Time of day concrete was placed
- Any test results of the concrete
- Contractor who placed the concrete
- Supplier of the concrete
- Concrete Mix design

- Placing methods

**Remember:**

**ALL CONCRETE CRACKS!**



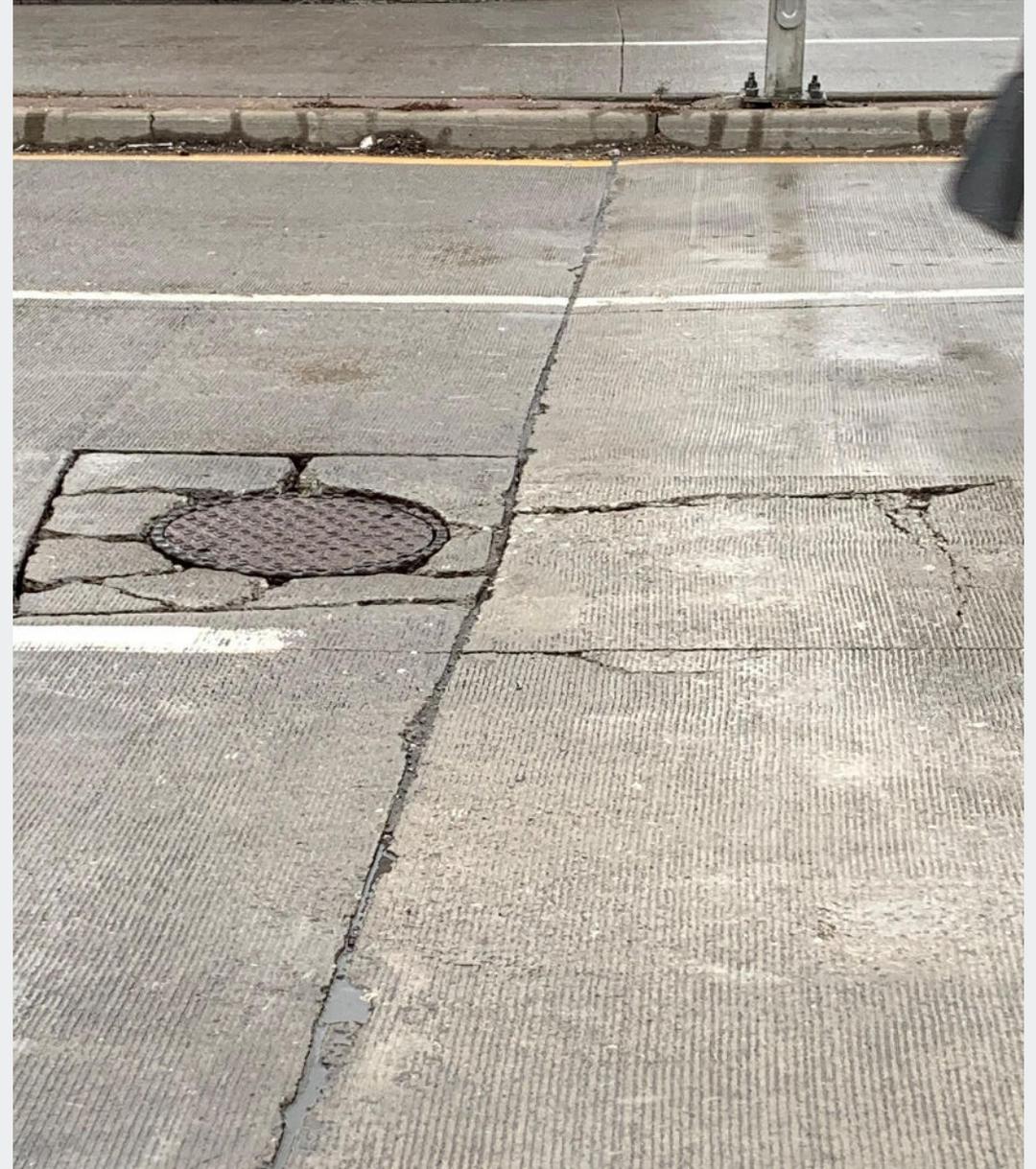
# Distresses in Concrete Pavements

## •Cracking

- Longitudinal and Meandering
- Diagonal, Corner and Edge Crescent
- D-cracking
- Transverse

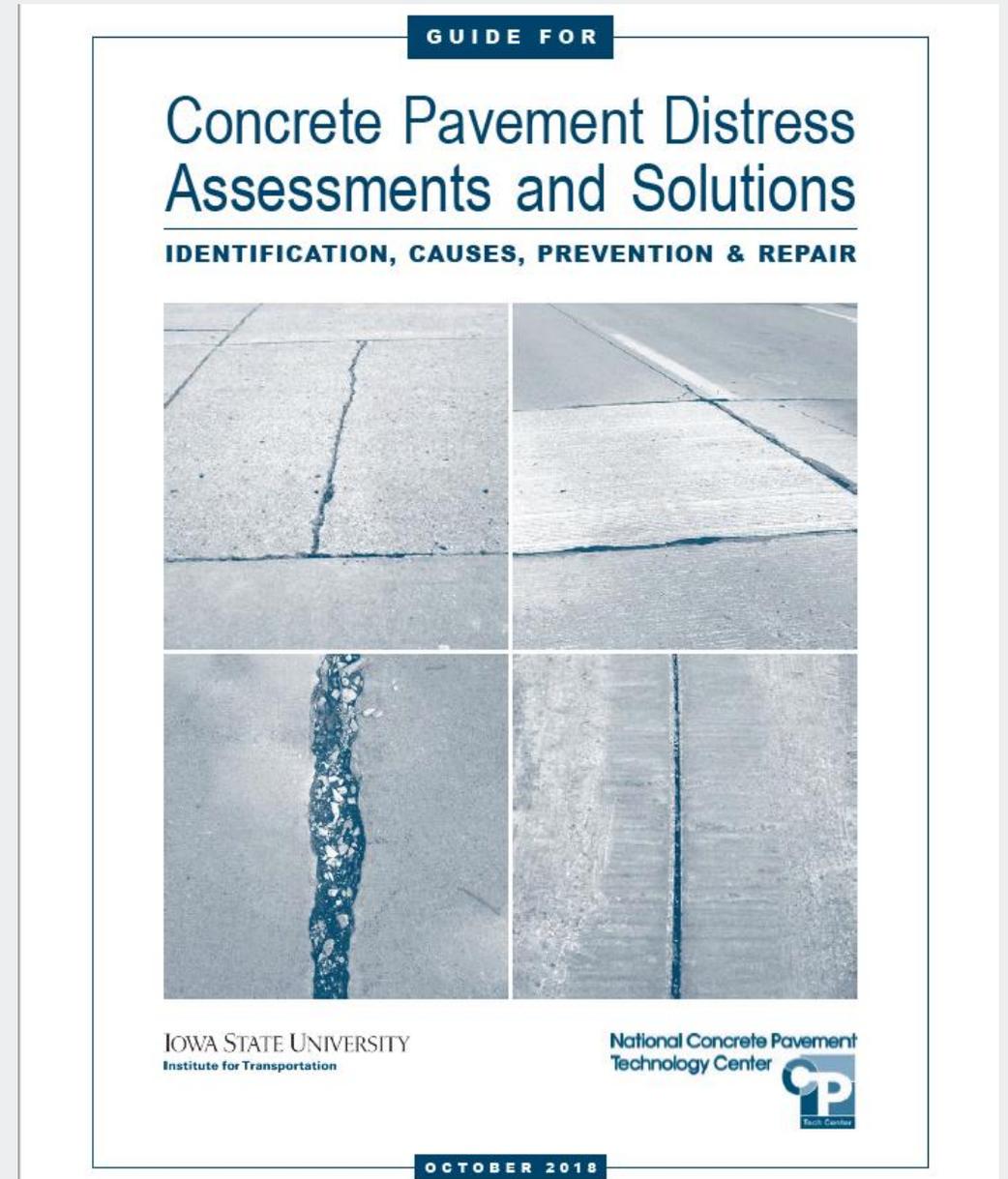
## •Joint Deficiencies

- Joint Sealant Loss
- Transverse Joint Creep
- Longitudinal Joint Separation
- Joint Failure (Blow ups)
- No isolation Joint



# Distresses in Concrete Pavements

- **Surface Defects**
  - Polishing
  - Scaling / mortar flaking
  - Joint / Crack Sealing
  - Blisters
  - Cracking
  - Delamination
  - Dusting
  - Discolouration
  - Popouts
  - Pumping
- **Structural Deformations**
  - Faulting (Stepping)
  - D-cracking
  - Blow-ups
  - Distortion



# Surface Defects



# Surface Defects in Concrete Pavements

## • Common Defects

- Map Cracking
- Plastic Shrinkage cracking
- Scaling
- Surface Polishing
- Surface wear in wheel path
- Popouts / mortar flaking
- Delamination

## • Causes

- Water to Cementitious ratio
- Concrete Mix Designs
- Aggregate Characteristics
- Abrasion Resistance
- Alkali-aggregate reaction
- Deicing Salts
- Surface Finishing Delamination
- Dusting
- Absorption of Mixing Water Into the Aggregate
- Curing
- Rain
- Weather
- Clay Balls
- Traffic



# Map Cracking (Crazing)

## What is it

- Chicken wire or cracked egg” pattern of fine cracks
- Does not penetrate much below surface. Usually do not affect concrete service life.
- Visible when concrete is drying after surface has been wet

## Cause

- Over working / over finishing of concrete surface
- Rapid surface drying after setting
- Applying dry cement to surface during finishing
- Late or Inadequate Curing
- Batching absorptive aggregates
- Alkali-aggregate Reaction (AAR)
- Finishing the concrete with bleed water on top. This increases the ratio of water to cement, creating a weak surface layer.



# Map Cracking (Crazing)

## Prevention:

- Use Moderate Slump Mixtures with Low w/cm ratio
- Use durable, nonreactive aggregates
- Use SCMs or Blended Cements to Control ASR
- Design Concrete with low permeability
- Keep stockpiles wet
- Use proper finishing practices
- Use effective curing practices



# Alkali-Aggregate Reactivity (AAR)

## What is It

Alkali-Aggregate Reactivity is the result of the chemical reaction of the Alkalis in the cement react with certain aggregate particles.

This reaction produces a Alkali-Silica or Alkali-Carbonate jell around a particle.

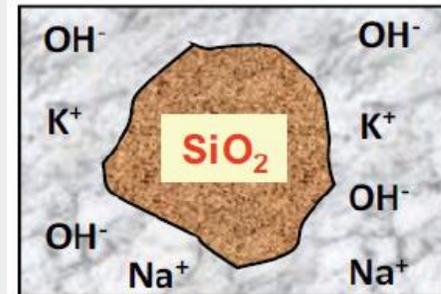
This jell expands the aggregate and results in a defect similar to Spalling.

## Cause

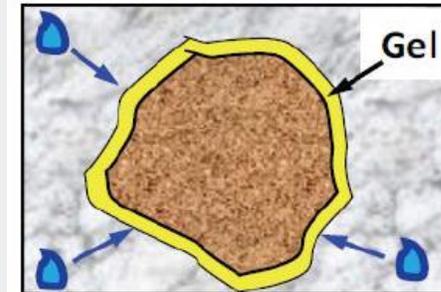
- Use of reactive Aggregates

## Prevention

- Specifying non-ASR potential aggregates

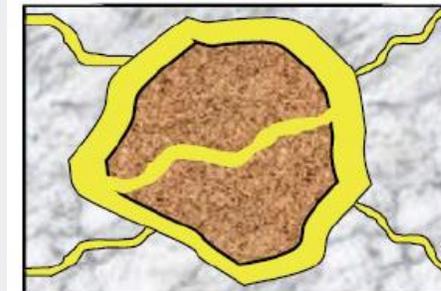


Reaction between the alkali hydroxides (Na, K & OH) from the cement and unstable silica, SiO<sub>2</sub>, in some types of aggregate.



The reaction produces an alkali-silica gel.

The gel absorbs water from the surrounding paste ...



... and expands.

The internal expansion eventually leads to cracking of the surrounding concrete.

# Plastic Shrinkage Cracking

## What is it

When that water eventually leaves the slab, it leaves behind large voids between the solid particles. These empty spaces make the concrete weaker and more prone to **cracking**. This type of **cracking** happens frequently when concrete is improperly cured and is referred to as “plastic **shrinkage cracking**”

- Concrete shrinks about 1.6 mm for every 3 m length (1/16 in./10 ft)
- Drying shrinkage dependent on water content of concrete
- Control joints predetermine location of drying shrinkage cracks



# Plastic Shrinkage Cracking

## Causes

- Rapid shrinkage cracking
- Caused by rapid evaporation of water from the surface before the concrete sets
  - Wind
  - Low humidity
  - High temperatures
- Varying length and spacing
- Often do not penetrate full depth.



# Plastic Shrinkage Cracking

## Prevention:

- Use durable mixes with low w/cm ratio
- Avoid high-shrinkage aggregates
- Use largest coarse aggregate possible
- Minimize cement contents
- Reduce aggregate absorption
- Use effective curing practices
- Employ proper hot and cold weather paving practices
- Do not use excessive amounts of sand
- Use water-reducing admixtures
- Avoid calcium chloride
- Provide proper jointing



# Scaling

## What is it

Physical deterioration of the upper concrete slab surface, normally 0.1 to 0.5 in. (3 to 13 mm) may occur anywhere on the pavement.

- **Cause**

- Freeze-thaw and deicing chemicals
- Improper surface finishing and curing
- Damage from rain

- **Prevention**

- Minimize the use of deicing chemicals
- Protect slab from rain
- Ensure proper air void system
- Use proper finishing practices
- Use effective curing practices



# Pop-outs

## What is it

Conical fragment that breaks from the concrete surface. A fractured aggregate particle is often at the bottom of the hole.

- Most appear in first year.
- Typical size: 5 mm to 50 mm (1/4 in. to 2 in.)
- Moisture enters the aggregate particle and during freezing, expands and breaks apart the particle, lifting off the concrete paste as well.



# Popouts

## Causes:

- Porous rock with high absorption, low specific gravity:
- Pyrite
- Hard-burned dolomite
- Coal
- Shale
- Soft, fine-grained limestone
- Chert
- Alkali-aggregate reactivity

## Prevention:

- Use low slump, low water content mix
- Use durable crushed stone or beneficiated aggregate
- Slope the slab surface to drain water properly
- Use supplementary cementing materials to control ASR-induced popouts



# Mortar Flaking

## What is it

A form of scaling over coarse aggregate (“popoffs”)

- Excessive and early moisture loss from the surface is accentuated over aggregate. Thin mortar layer breaks off upon freezing in a saturated condition
- **Cause:**
  - Delayed curing is the most likely the cause.

## Prevention:

- High-quality, **air-entrained** concrete
- Proper finishing and curing
- Proper drainage
- Sufficient air drying before winter



# Surface Polishing or Surface Wear

## What is it

Abrasive wear under traffic of the pavement surface texture and the aggregate, creating a smooth and polished surface.

## Cause

- Use of aggregates with poor abrasion resistance
- Exposure to traffic
- Improper surface finishing and curing

## Prevention:

- Use wear-resistant aggregates
- Minimize moisture loss
- Use concrete mixtures with adequate strength
- Use proper finishing practices
- Use effective curing practices



# Surface Delamination

## What is it

Essentially big blisters:

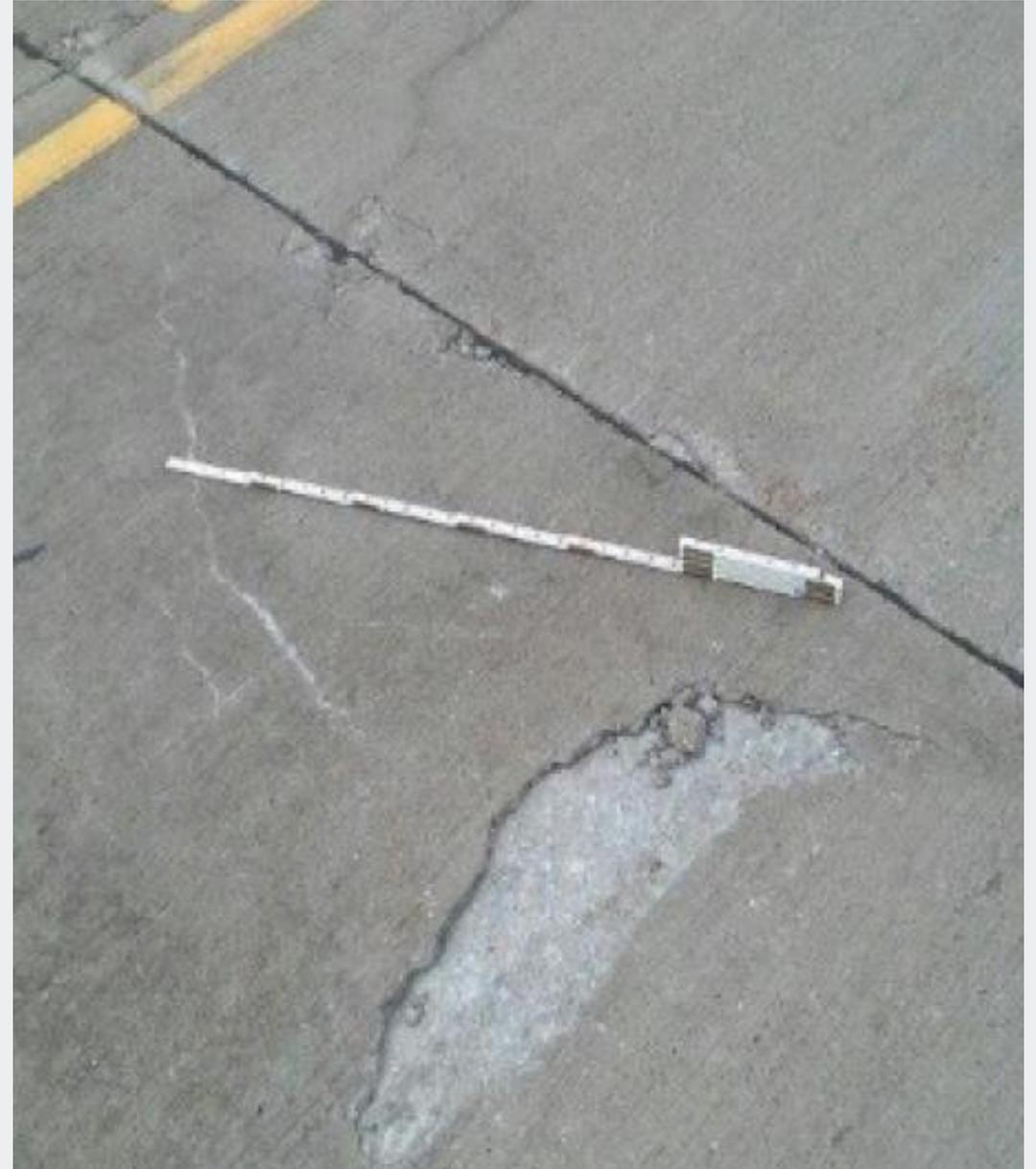
Surface mortar is separated from underlying concrete by rising water and air that are trapped beneath a finished surface.

## • Causes of Delamination

- Concrete placement operations
- Concrete finishing operations
- Curing
- Jointing
- Traffic loading
- Compression Shear with Weakened plane
- Steel Placement and Corrosion
- Water/ Cementitious Materials (W/cm) ratio

## • Treatment

- Diamond grinding the surface



# Treatment Options for Concrete Pavement Surface Defects

Distress	Treatment Penetrating Sealer	Treatment: HMWM	Treatment: Void Filling	Treatment: Diamond Grinding	Treatment: Slab Replacement	Treatment: Overlay
Map Cracking Construction Factors		May be applicable if cracks are sufficiently deep		Map cracks generally require no repair, but may use DG to improve aesthetics		
AAR Factors		Has been used to help “glue” distressed pavement together and keep water out to slow the AAR progress				Unbonded overlay solutions only, and then only after careful evaluation of extent and severity of AAR
Plastic Shrinkage Cracking		May be considered for deeper cracks				

# Treatment Options for Concrete Pavement Surface Defects

Distress	Treatment Penetrating Sealer	Treatment: HMWM	Treatment: Void Filling	Treatment: Diamond Grinding	Treatment: Slab Replacement	Treatment: Overlay
Scaling	Used as Preventive method prior to salt scaling			Diamond grinding can restore smoothness and aesthetics	Only used if extremely severe scaling throughout an entire slab	Used when deterioration is too severe and too widespread for other treatments
Surface Polishing / Surface Wear				Surface texture improvements may be temporary		Thin asphalt or concrete overlays
Popouts / Mortar Flaking / clay balls	May help waterproof the surface		Filling of voids with agency approved repair material	DG used to improve aesthetics		Thin asphalt or concrete overlays



# Surface Delamination

## Prevention and Mitigation Strategies for Surface Delamination in Concrete Pavements

Causes	Design	Prevention: Material Selection	Prevention: Construction	Prevention: Maintenance
Concrete mix-related issues including a high w/cm ratio, paste content, CTE, and reactive aggregates	<p>Use low w/cm ratio mixes where possible</p> <p>Design concrete mixes for low permeability</p>	<p>Use low paste content mixes where possible</p> <p>Do not use high alkali or reactive aggregates if possible; if needed, use SCMs as a mitigation strategy</p>	Adjust concrete workability with admixtures rather than the w/cm ratio	N/A
Poor concrete placement and finishing operations	N/A	N/A	<p>Ensure that segregation does not occur during placement</p> <p>Consolidate the concrete to remove entrapped air but not so much as to remove entrained air or segregate the concrete</p> <p>Do not finish until the surface water sheen dissipates</p> <p>Initiate curing as soon after placement and finishing as possible</p>	N/A

Reference: Concrete Pavement Distress Assessments and Solutions

# Surface Delamination

## Prevention and Mitigation Strategies for Surface Delamination in Concrete Pavements

Causes	Design	Prevention: Material Selection	Prevention: Construction	Prevention: Maintenance
Jointing	Design the transverse joints based on the CTE of the concrete, environment, and subgrade or base/slab friction	N/A	Saw cut joints in a timely manner and to the correct dimensions	Maintain joint sealant to minimize moisture intrusion and incompressible materials from entering joints
Embedded steel	N/A	Use corrosion-resistant steel if in a corrosive environment  Use a low permeability concrete mix	Verify that the steel is placed at the correct depth to ensure a sufficient depth of cover	N/A

Reference: Concrete Pavement Distress Assessments and Solutions



# **Joint / Crack Deterioration**



# Joint / Crack Deterioration

**Joint/crack deterioration** can be defined as:

- Joint opening that is spalling or has a blow-up

## •Causes:

- Incompressible material in joint/crack
- Material durability problems
- Improper sealant installation
- Curling and warping of slabs

## •Treatment Option:

- Partial / full depth repairs



# Transverse Cracking

**Transfer cracking** can be defined as:

Cracks perpendicular to the pavement's centerline or laydown direction

## Causes:

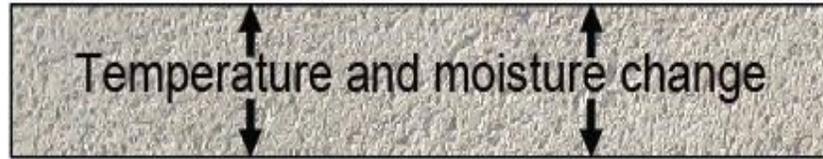
- Loading (Fatigue)
- Long Joint Spacing
- Shallow/Late sawing
- Locked joint(s)
- Curling/Warping
- Loss of Support
- Settlement/Heave
- Base/Edge Restraint

## •Treatment Option:

- Partial / full depth repairs



# Curling and Warping



- Variations in contraction and expansion cause differential, non-uniform movements

**Curling** => Change in **Temperature**  
**Warping** => Change in **Moisture**

- These movements, especially when restrained, can cause cracking

(IMCP—page 155)



**Temperature curling**



**Moisture warping**



**Hot days  
(curling  
counteracts  
warping)**



**Temperature curling**



**Moisture warping**



**Cool nights  
(curling  
compounds  
warping)**

(IMCP—pages 150–151)

# Curling and Warping

Curling can be reduced by:

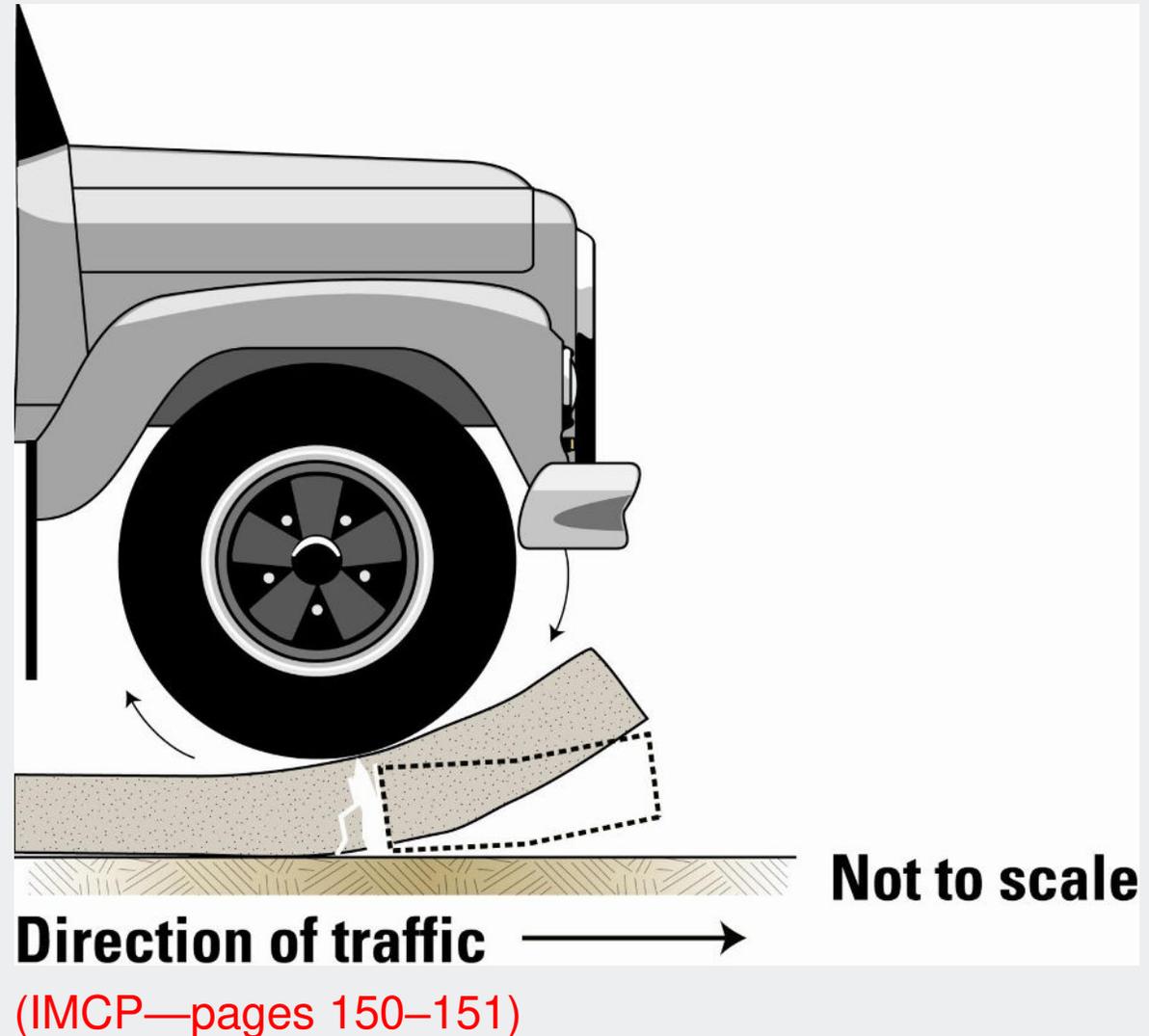
- Low-shrinkage concrete
- Shorter joint spacing
- Uniform moisture and temperature
- Reinforcing steel
- Thickened slab edges
- Vacuum dewatering, shrinkage-compensating concrete, post-tensioning

Curling often subsides with time

**Treatment options:**

Joint cutting

Grinding and undersealing



# Corner Cracking

**Corner cracking** can be defined as:

- A crack that intersects the slab joints near the corner

- **Causes:**

- Loss of support
- Pumping of fines
- Long joint spacing
- Curling/warping
- Settlement/heave

- **Treatment Option:**

- Slab jacking
- Full depth repair
- Subdrain at shoulder area



# Longitudinal Cracking

- **Longitudinal Cracking** can be defined as:
  - Cracks parallel to the pavement's centerline or laydown direction

## Causes:

- Near Centerline:
  - Shallow/late joint sawing
  - Varied thickness of pavement
- Near Edge:
  - Shallow/late joint sawing
  - Loading
  - Loss of support
  - Settlement/heave



# D-Cracking

Pavement shows a D-shaped deterioration of the pavement at joint locations due to using absorptive aggregates.

## Causes :

- *Moisture, freeze-thaw, susceptible aggregates (e.g., limestones).*

## Prevention:

- Specifying non susceptible aggregates

## Treatment options:

- *Slab replacements for localized areas, but reconstruction is the only alternative to completely deal with the problem.*



# Faulting

Differential vertical displacement of abutting slabs at joints or cracks

## Causes:

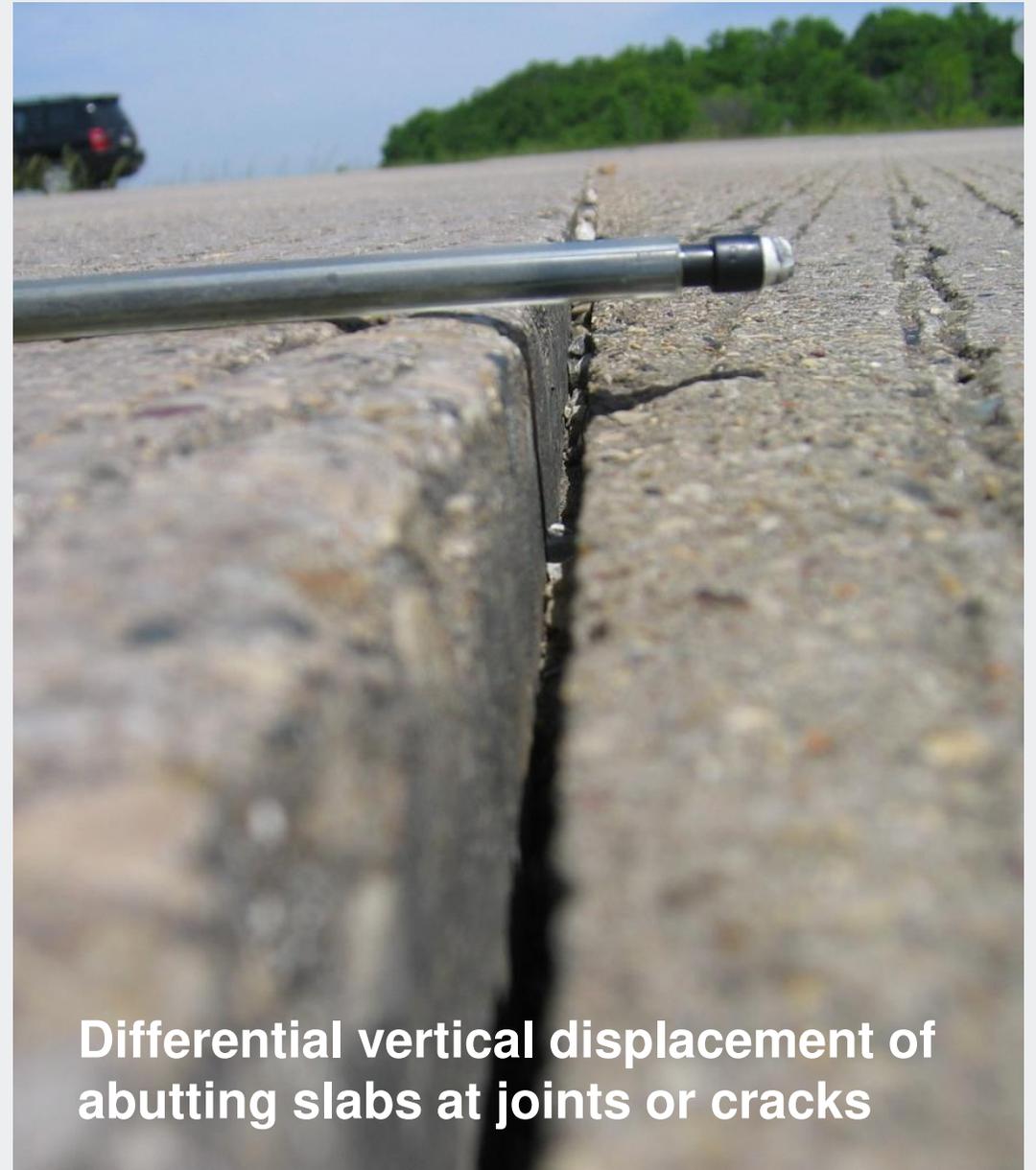
- Poor Load Transfer
- Loss of support
- Pumping of fines
- Under compressive strains
- Expansion of freezing water

## Prevention:

- Install dowels

## Treatment options:

- Dowel Bar retrofitting
- Diamond grinding
- Slab stabilization



Differential vertical displacement of abutting slabs at joints or cracks

# Joint Spalling

Spalling is similar to scaling except large chunks instead of just flakes break loose.

This indicates a weakness in joint face of the concrete pavement.

## Causes:

- Weaker concrete at joint sides which spall of when sealant bond is stronger than the concrete. Over time the sliver spall grows creating a pothole like depression.



# Blow-ups

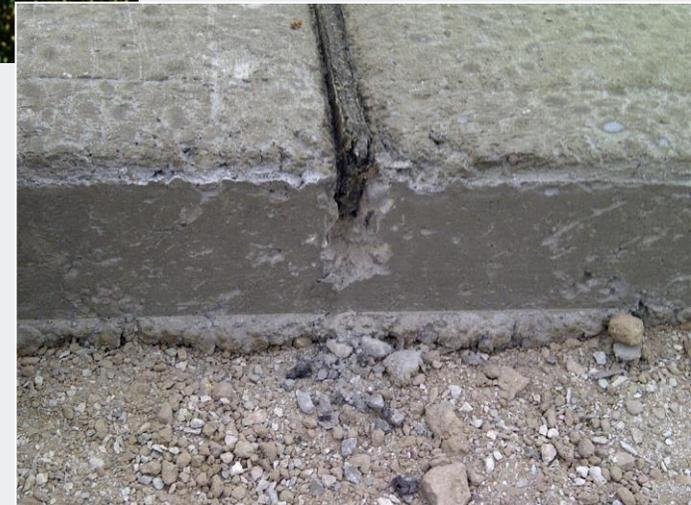
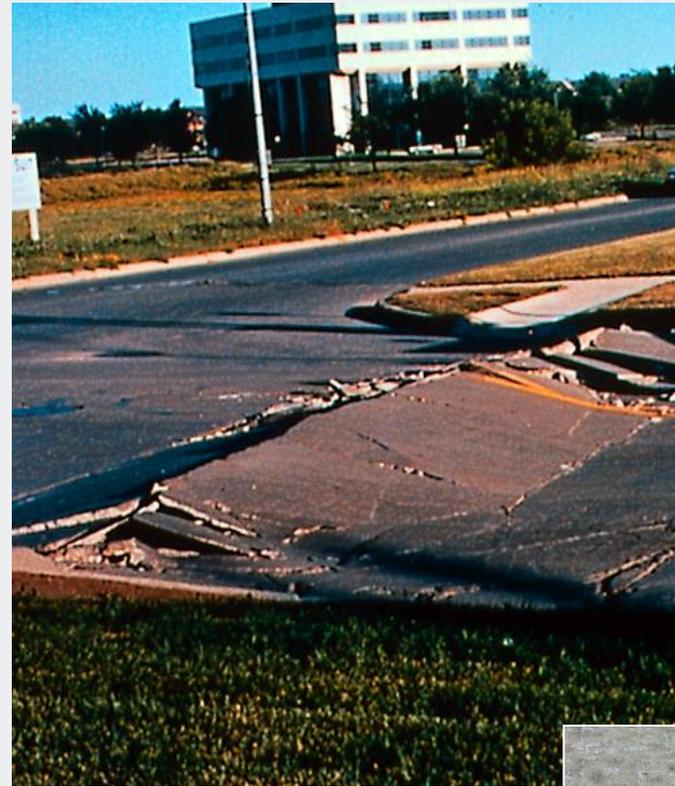
A blowup is a result of localized upward movement or shattering of a slab along a transverse joint or crack (FHWA, 2014). Blowups often occur in the heat of the day as expansion results in a buildup of pressure that can be dramatically released as the pavement thrusts upwards and/or shatters.

## Causes:

- Incompressibles in joints,
- ASR,
- high temperatures.
- Improper Isolation Joints

## Treatment options:

- *Slab replacements.*



# Key Points for Reducing Early-Age Concrete Cracking

1. Optimize the size and amount of **coarse** aggregate
2. Use low **shrinkage** aggregate to minimize shrinkage that may cause cracking
3. Consider using a **water reducing** admixture to reduce paste content
4. Use **SCM** to help reduce the set temperature and the temperature peak
5. Avoid **calcium chloride** admixtures, which can significantly increase drying shrinkage
6. Time concrete **placement** so that the temperature peak does not coincide with the hottest time of day
7. Prevent rapid loss of surface **moisture** while the concrete is still plastic
8. If the **ambient** temperature is likely to drop significantly, cover the pavement surface with blankets to slow heat loss and prevent extreme differentials in temperature through the slab

(IMCP—page 155)



# Pay Attention to Details



# THANK YOU!

## QUESTIONS?

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My New Office

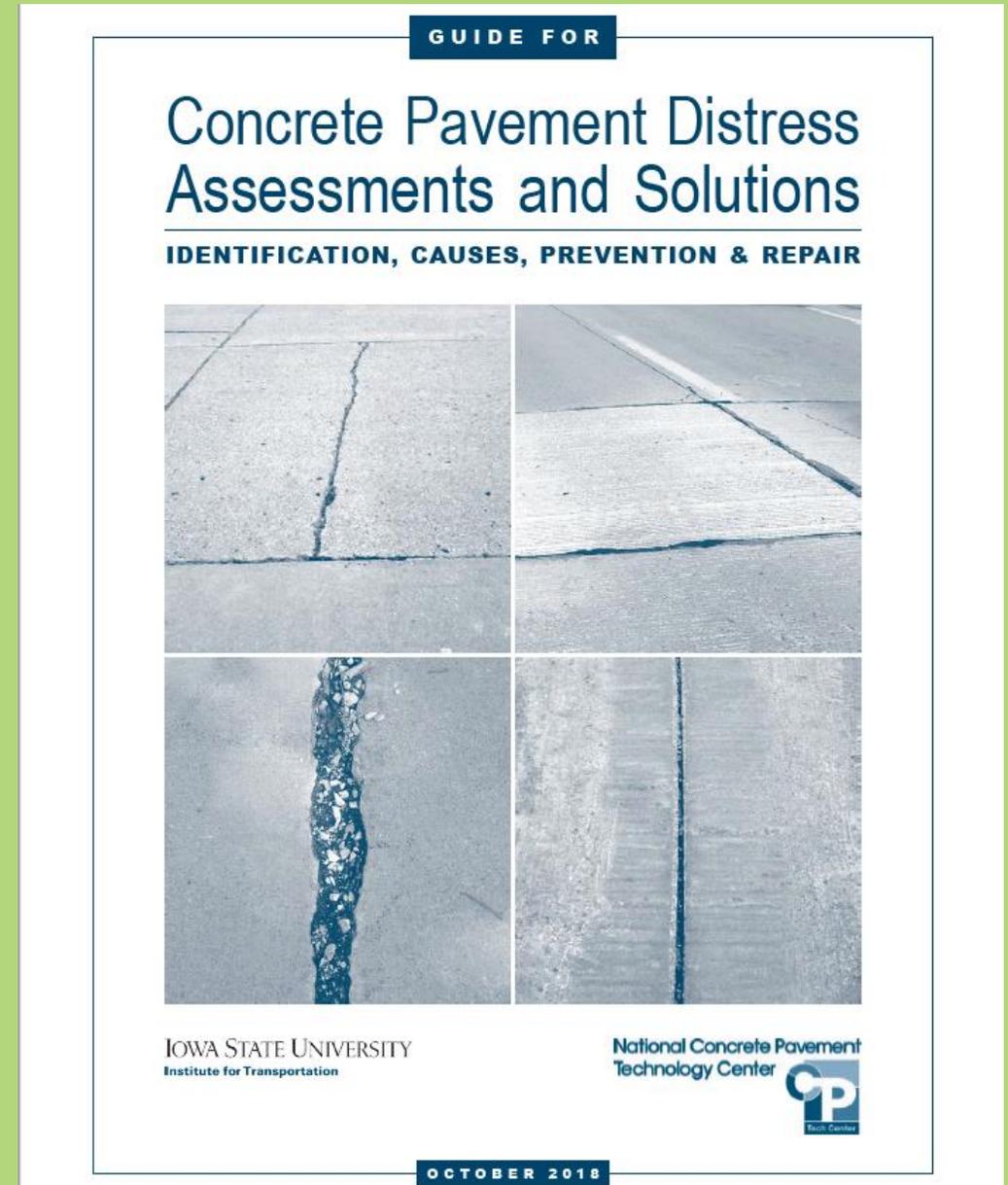


# **APPENDIX: Technical Resources**



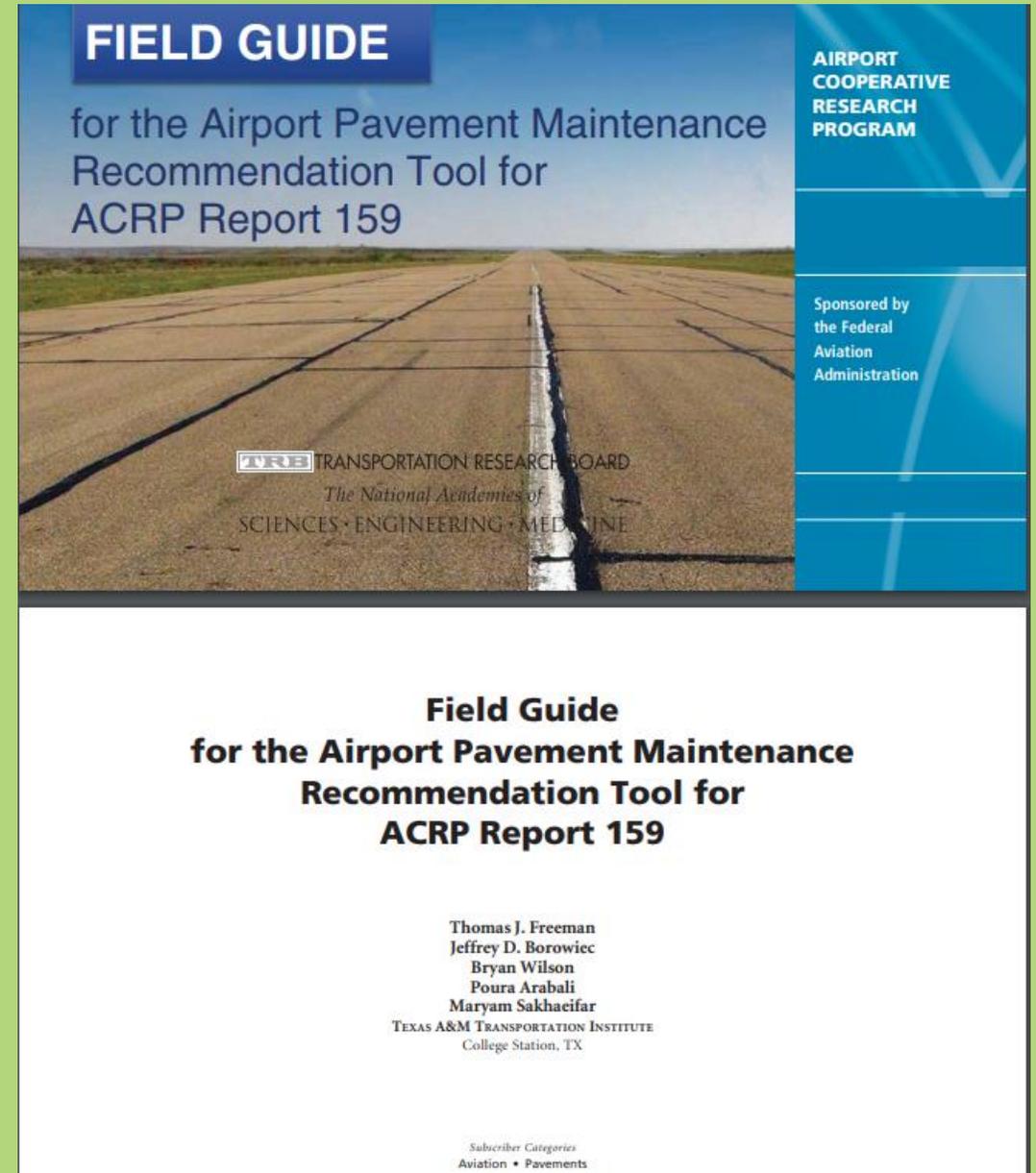
# Concrete Pavement Distress Assessments and Solutions

- Surface Defects
- Surface Delamination
- Materials- Related Cracks
- Transverse and Diagonal Cracking
- Corner Cracking
- Spalling – Transverse and Longitudinal Joints and Cracks
- Faulting
- Joint Curling and Warping
- Blowups
- Subgrades and Base Support Conditions



# Filed Guide for the Airport Pavement Maintenance Recommendation Tool for ACRP Report 159

- Step 1. Determine Airport Classification
- Step 2. Choose Climatic Zone
- Step 3. Identify Distress
- 4. Determine Treatment
- Concrete Pavement Treatment
- Concrete Pavement Maintenance Treatment Hierarchy



# Guide to the Prevention and Restoration of Early Joint Deterioration in Concrete Pavements

- Types and Mechanisms of Joint Deterioration
- Preventing Joint Deterioration in New Pavements
- Maintenance Activities to Reduce Joint Deterioration Risk
- Treatment of Pavements with Joint Deterioration
- Specification Guidelines

GUIDE TO THE  
PREVENTION AND RESTORATION  
OF EARLY JOINT DETERIORATION  
IN CONCRETE PAVEMENTS

DECEMBER 2016



# Rapid Slab Repair and Replacement of Airfield Concrete Pavement

- Planning Repairs
- Partial-Depth Repairs
- Full-Depth Repairs
- Airport Case Examples
- Examples of Rapid Slab Repair and Replacement Projects

AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP RESEARCH REPORT 234

## Rapid Slab Repair and Replacement of Airfield Concrete Pavement

Jeff Stempihar  
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APPLIED PAVEMENT TECHNOLOGY, INC.  
Urbana, IL

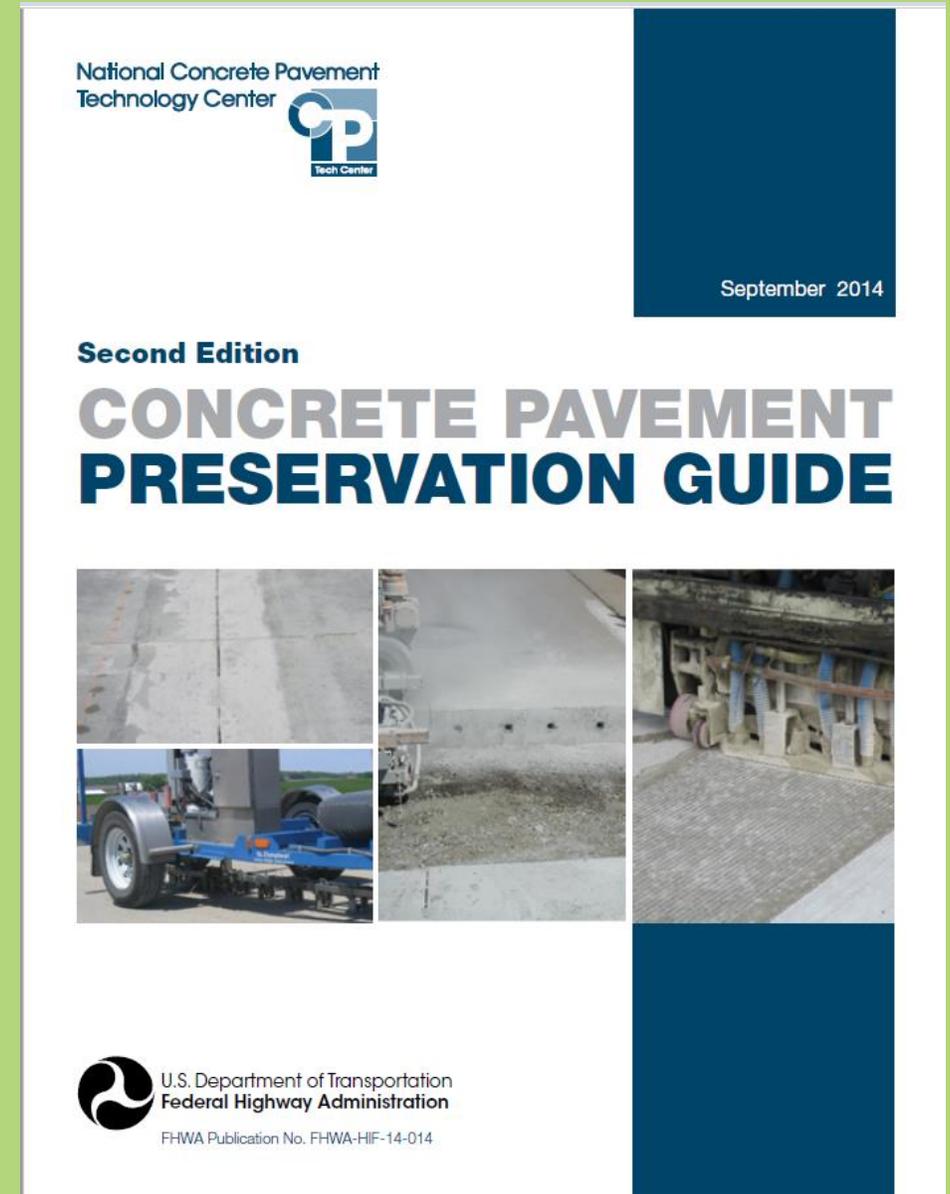
*Subscriber Categories*

Aviation • Design • Pavements



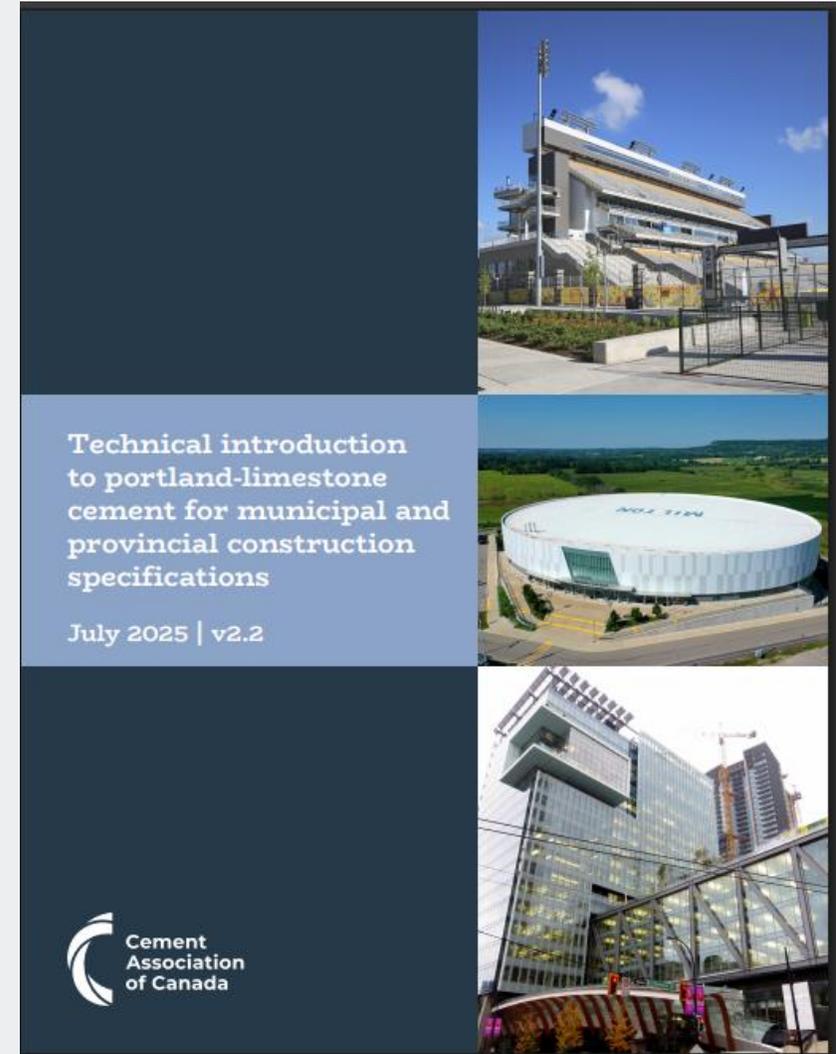
# Concrete Pavement Preservation Guide

- Pavement Maintenance and Pavement Preservation Concepts
- Concrete Pavement Evaluation
- Slab Stabilization and Slab Jacking
- Partial-depth Repairs
- Full Depth Repairs
- Retrofitted Edge Drains
- Dowel Bar Retrofit, Cross Stitching and Slot Stitching
- Diamond Grinding and Grooving
- Joint Resealing and Crack Sealing
- Concrete Overlays
- Strategy Selection



# PLC Technical Summary Document

- What / why Portland Limestone Cement
- How is PLC Manufactured
- History of PLC Use
- Testing and Performance
- Use in Other Jurisdictions
- Carbon Reduction Potential
- Summary
- Key Contacts
- References
- Appendix A: Project Examples
- Appendix B: Case Study on GU vs GUL

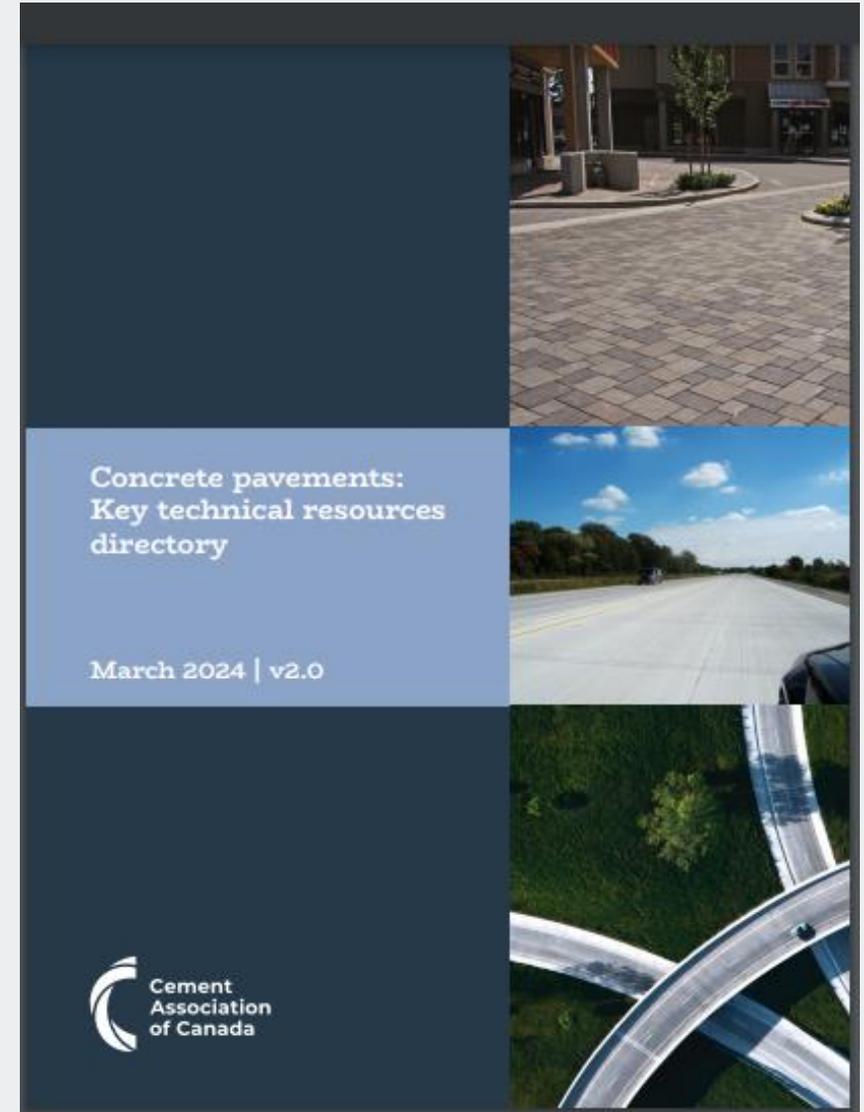


<https://cement.ca/wp-content/uploads/2025/07/PLC-Technical-Summary-Report-v2.2.pdf>



# Concrete Pavement: Key Technical Resources

- Notes airport pavement design software
- Links to FAA tools and resources for airports



<https://cement.ca/wp-content/uploads/2024/03/Concrete-Pavements-Key-Technical-Resources-Directory-2.0.pdf>

